Center Innovation Fund: KSC CIF

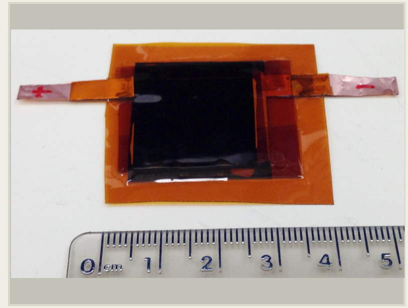
Flexible Graphene-Based Energy Storage Devices for Space Application

Completed Technology Project (2012 - 2014)

Project Introduction

The purpose of this project is to develop a graphene-based battery/ultra-capacitor prototype that is flexible, thin, lightweight, durable, low cost, and safe and that will demonstrate the feasibility for use in aircraft. These graphene-based devices store charge on graphene sheets and take advantage of the large accessible surface area of graphene to increase the electrical energy that can be stored. The proposed devices should have the electrical storage capacity of thin-film-ion batteries but with much shorter charge/discharge cycle times as well as longer lives. The proposed devices will be carbon-based and so will not have the same issues with flammability or toxicity as the standard lithium-based storage cells.

Several methods for the production of graphene have been developed in recent years. The most promising techniques for the production of high-quality bulk graphene-based devices begin with graphite oxide (GO). Several methods to reduce GO have been developed, including chemical, thermal, and flash reduction. Not all of these methods produce high quality graphene and the ones that do, use relatively expensive equipment. A new and inexpensive solid state method developed by this proposal's co-investigator at University of California Los Angeles (UCLA) produces high quality graphene films with a surface area of 1500 m2/g, which is much larger than that reported for thermally or chemically converted graphene. Oxygen reduction with this method reaches much higher values than the more widely used chemical reduction method. These graphene sheets are mechanically strong, have high electrical conductivity, and can be used directly as electrodes in energy storage devices. This form of graphene is potentially useful for ultracapacitors with remarkable energy and power densities. A new experimental setup for the reduction of GO based on the University of California Los Angeles laser-scribed graphene (LSG) method was designed at the Kennedy Space Center laboratory. This new method uses a diode pumped laser system with tunable power and short wavelengths. After a few months of optimization, the method successfully produced high quality graphene electrodes. This process results in graphene with a reduction level that is superior to traditional methods for the reduction of GO. This low oxygen content is required for building durable supercapacitors. X-Ray Photoelectron Spectroscopy (XPS) analyses of the graphene sheets that we have produced show that the carbon content of the films ranges from 96% to 98.5% while the oxygen content is in the range of 1.4% to 3%. By comparison, more widely used chemical reduction methods reduce oxygen content to 10% or higher. The carbon and oxygen content of the unreduced graphene oxide ranges between 66% to 70% and 29% to 32% respectively. Graphene electrode sheets were made into solid squares for parallel-plate laser-scribed electrochemical capacitors (LSG-EC). LSG-ECs were driven through multiple charge/discharge cycles at the UCLA laboratory. The devices lose only about 3% of its capacitance after 10,000 cycles. The shelf life of these devices was also measured. The capacitancs of these devices is retained after 120 days.



Thin film graphene ultracapacitor prototype made at KSC

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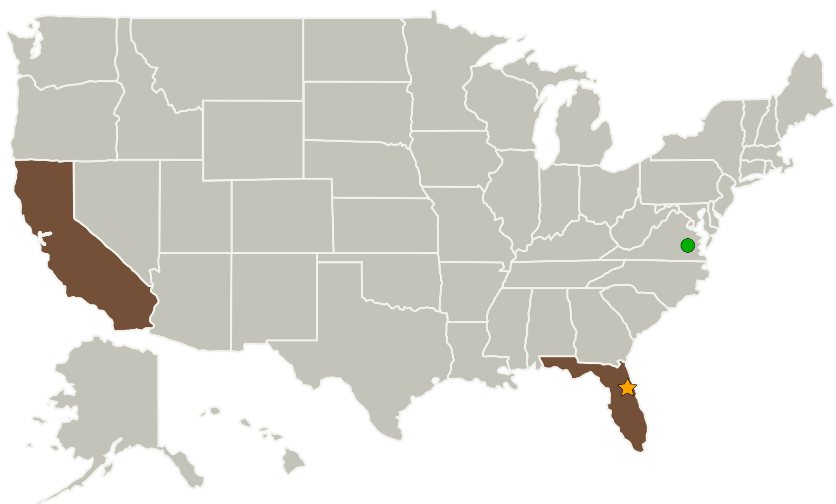
Anticipated Benefits

Crew exploration missions, habitats, planetary probes, rovers and landers, orbiters, life support systems will benefit from these revolutionary devices

There is a clear and stated need for such flexible, lightweight and low volume batteries for commercial and military applications. Applications include rugged batteries for smart phones, energy storage for solar panels, and wearable batteries.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Kennedy Space Center(KSC)	Lead Organization	NASA Center	Kennedy Space Center, Florida
●Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia
QinetiQ North America(QNA)	Supporting Organization	Industry	

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Kennedy Space Center (KSC)

Responsible Program:

Center Innovation Fund: KSC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Barbara L Brown

Project Manager:

Nancy P Zeitlin

Principal Investigator:

Carlos I Calle

Co-Investigators:

Richard Kaner
Paul J Mackey

Flexible Graphene-Based Energy Storage Devices for Space Application

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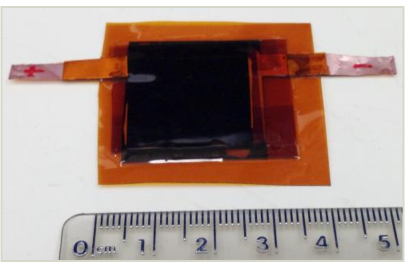
Co-Funding Partners	Type	Location
University of Southern California(USC)	Academia	Los Angeles, California

Primary U.S. Work Locations	
California	Florida

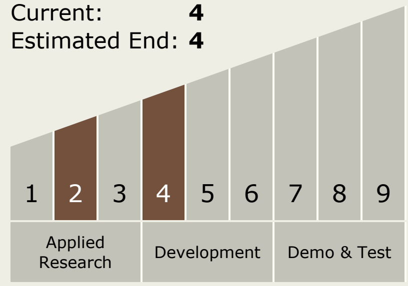
Images



Thin film graphene ultracapacitor prototype made at KSC
Thin film graphene ultracapacitor prototype made at KSC
(https://techport.nasa.gov/image/2626)

Technology Maturity (TRL)

Start: **2**
Current: **4**
Estimated End: **4**



Technology Areas

Primary:

- TX03 Aerospace Power and Energy Storage
  - └ TX03.2 Energy Storage
    - └ TX03.2.1 Electrochemical: Batteries